SCIENTIFIC WRITING

FCTUC Faculdade de Ciências e Tecnologia Universidade de Coimbra

A criar Ciência e Tecnologia desde 1772

1 2 9 0 UNIVERSIDADE D COIMBRA

Luis Adriano Oliveira

2025-07-04

Summary

- Motivation and objectives
- Companion book. Further reading
- Main phases of the research process
- The communication process: agents, factors
- What characterizes a good scientific text

Part I

- A concrete example: master's dissertation/doctoral thesis
- Hands on: practical suggestions
- Concluding remarks

Part II

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Motivation – I

- "It's enough for scientists to do good science. I'm an Engineering student, not a Literature one!!"

- The viva: "Didn't have enough time to write"!!

Motivation – II

nº. of researchers
funding

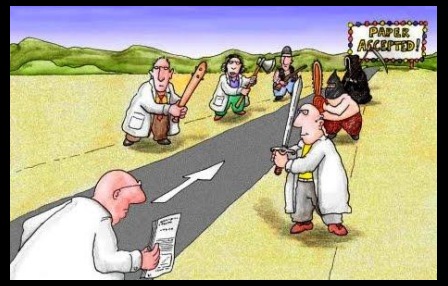
- Pressure to publish
  "publish or perish"

  - temptation to underestimate research quality

  - temptation to underestimate research report

    - **insufficient time allocated to writing**
    - **insufficient care given to text and alike (form and contents)**
    - a good report does not ensure research quality, but…
    - … a bad report can completely spoil (crash!) a good research!!

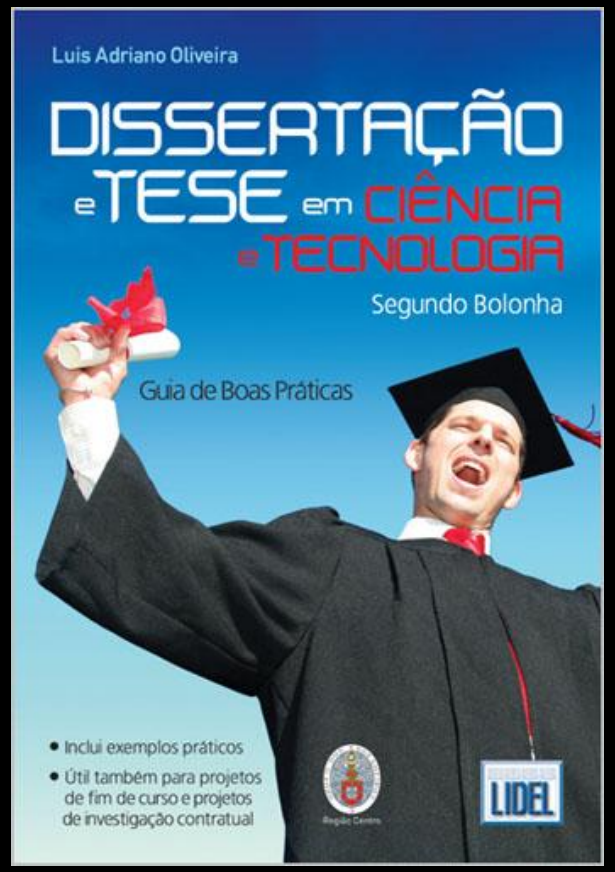
Objectives

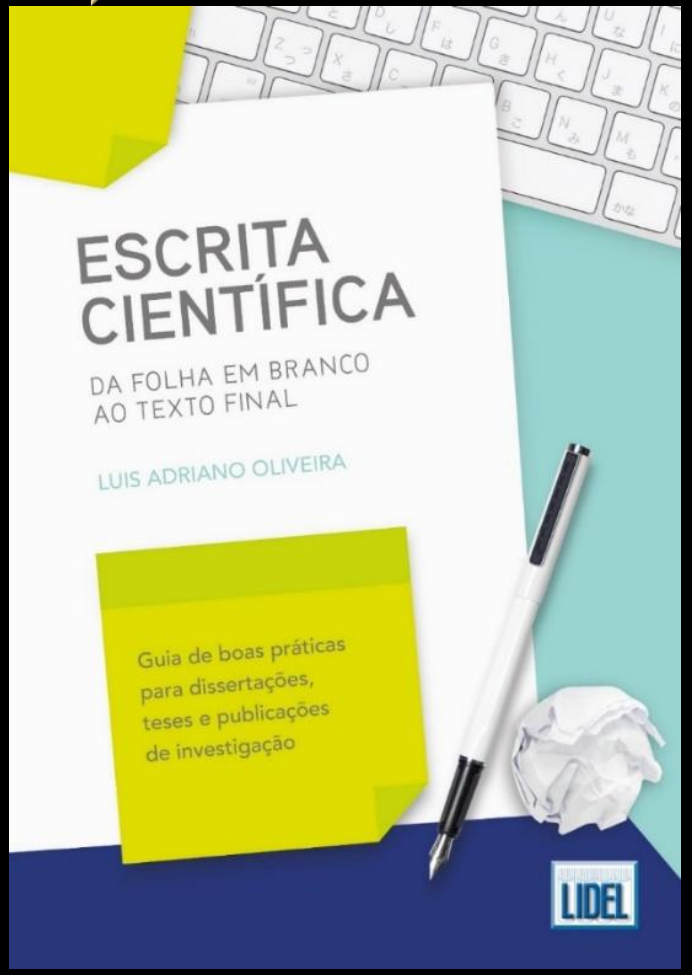


- Help you improve the impact of your research report
  - theses and alike:
    - ✓templates are often provided by hosting institutions
  - journal papers e congress communications:
    - ✓instructions to authors provide necessary (though not sufficient) indications to ensure that manuscripts are accepted for publication
- A ‘guide for good practices’ is a useful tool…

  … but no more than that!!

Companion books (in Pt)





- OLIVEIRA, L. A. (2014) - "Dissertação e Tese em Ciência e Tecnologia" (3.ª ed.), *Lidel*.
- OLIVEIRA, L. A. (2018) - "Escrita Científica: da Folha em Branco ao Texto final", *Lidel*.
- OLIVEIRA, L. A. (2024) - "Responsabilidade Ética e Profissional em Ciência e Engenharia", *Lidel*.

Further reading:

See appendix I

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Building scientific knowledge: the process includes three main phases

- 1 – Select and pose a question that needs an answer
- 2 – Collect data ('results') to find an answer to the question
- 3 – Share the answer with those interested

Building scientific knowledge: the process

1
- Select the scientific area and scope
- Read, deepen knowledge, think of deeply
- Characterize social context and importance
- State of the art: identify knowledge gaps
  - ✓ open questions are 'niche of opportunity'
- Select and pose **THE QUESTION**

2
- Original idea: set up a working hypothesis
  - ✓ prospective answer to the selected question
- Select instruments to obtain results
- Collect results
- Test and validate results (reliability → confidence)
- Explore, organize, interpret and discuss results
- Discussion leads to conclusions that answer the question

3
- Disseminate (share) the conclusions (answer to the question)

Main phase 3

- Disseminate (share) innovation:
  - ✓(i) orally, in person
  - ✓(ii) via **SCIENTIFIC WRITING**
- All the topics of phases 1 and 2 must be reported

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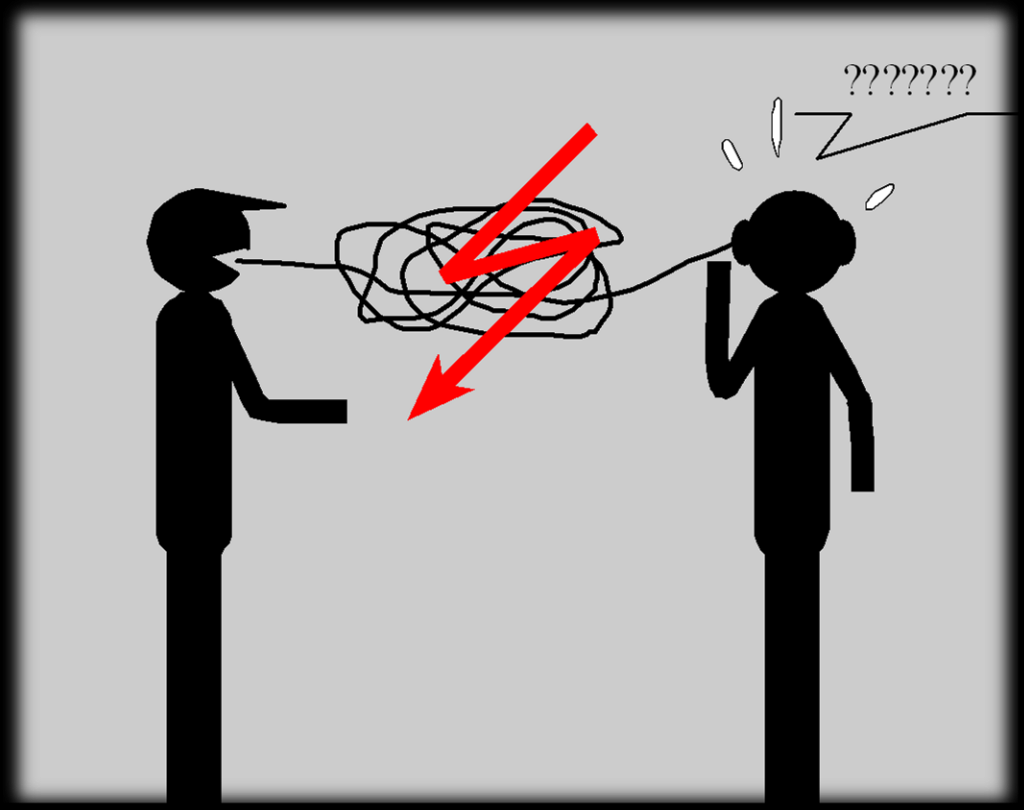
“Life is the art of encountering, although there are so many failed encounters in life”

(“A vida é a arte do encontro, embora haja tanto desencontro nessa vida!” – Vinicius de Moraes)

Communication

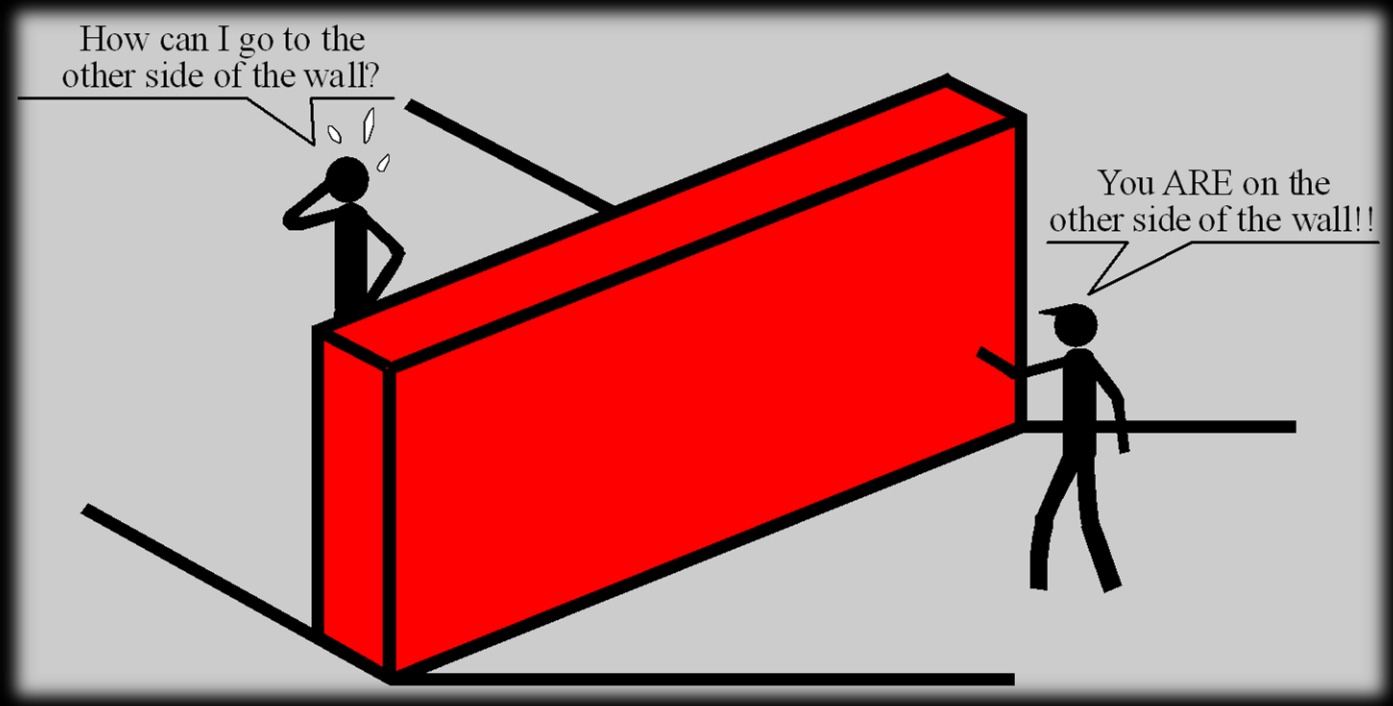
Like in the oral context,

writing is an art of communication…



… although there are so many failed,
written communications!

The issue of references…

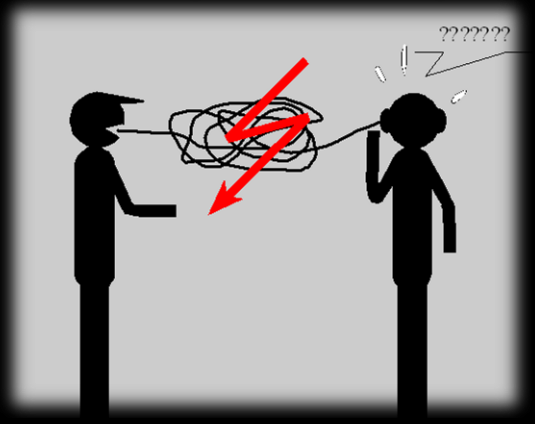


- If the author ignores the reader's references, communication will never work!

The communication process

- Agents
  - message (contents to communicate)
  - message sender
  - message receiver
  - propagation channel (physical support of message transfer)
    - digital or analogic
      - ✓telephone line, coaxial cable, optical fiber, radio frequency, computer file…
  - communication tool (instrument used to formulate the message)
    - ✓speech, writing, gesture, telephone, radio, television, cinema, journal, book, hard disk, media, Internet, website, painting canvas…

The communication process (cont.)



- Conditioning circumstances
  - surrounding <u>environment</u>
    - noise (interferences, either physical or psychological)
      - ✓during emission, transmission, and/or reception
  - receiver's level of preparation and receptivity
    - ✓education, culture, geography, religion, politics…

Written scientific communication: promoting factors

- Text respects logical reasoning
- Sufficient information provided to the reader
- Text sparks interest, curiosity, attention
  - highlights and illustrates importance (utility) of contents
- Attractive presentation
  - simple, clear, convergent (details: only if indispensable)
  - lively text, the essential in titles and subtitles
  - close to the reader's daily life
    - sparks emotion, surprise, complicity
  - **short sentences**, well punctuated (natural rhythm)

Written scientific communication: hampering factors

- Text challenges/subverts logical reasoning
- Information gaps
- Text does not spark interest, curiosity, attention
- Boring presentation

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Cold melon soup - recipe

- Cold melon soup with bacon (6 doses, 10 min)

  - Ingredients: diced bacon; 1 melon; cream (250ml); salt to taste; sugar to taste.
  - Preparation: crush the melon until very fine; add the cream, salt and sugar, stirring well; filter through a sieve and place in the refrigerator; pass bacon in a frying pan; serve well chilled, adding bacon bits.

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A good scientific text…

- Ensures reproducibility
  - the reader uses the text as a first step to perform his/her own research: first reproducing, then modifying
- If reproducibility is not respected:
  - loss of time and resources

✓e.g. trying to replicate something unrepeatable

A good scientific text…

- Disseminates knowledge and how it was acquired
- Reflects the fact that scientific knowledge is not based upon magic, authority or personal beliefs, but on arguments and proofs
- Follows a logical sequence, which is announced from the beginning
  - roadmap

A good scientific text… (cont.)

- Is <u>simple</u> and crystal clear, intelligible, yet rigorous
  - "ce qui se conçoit bien s'énonce clairement" (Boileau-Despreaux, 1674)

- Has the strictly necessary <u>extent</u>
  - "less is more"
  - "this text is too long because I didn't have enough time to make it shorter" (B. Pascal)
  - complementary information transferred from the body text to appendices, footnotes, references, *links*…

- Raises and/or anticipates <u>possible questions</u>

A good scientific text… (cont.)

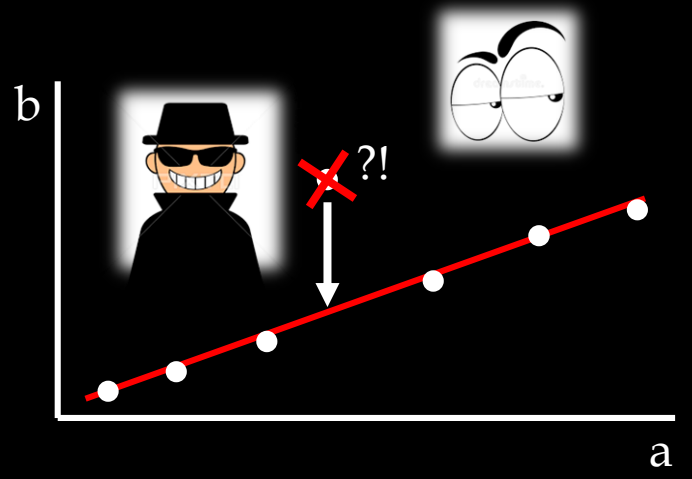
- Highlights and proves its usefulness. Three **contexts**:
  - application: illustrations close to reader's daily life
  - legitimacy: state of the art ⇒ filling knowledge gaps
  - innovation:
    - what innovation
    - how it was generated
    - how much trustworthy it is (tests, validation)
    - what conclusions it allows – or does not allow – to extract

A good scientific text… (cont.)

- Is ethically irreproachable

  - no questionable practices
    - ✓ negligent work, not intentional

  - no misconduct
    - ✓ deliberate, intention to deceive



  - FFP (the most serious scenario):

  - Fabrication (making up data or results)
  - Falsification (changing or misreporting data or results – even if through omission of important material)
  - Plagiarism (using the ideas or words or images of another person without giving appropriate credit)
    - software presently available to detect plagiarism (Urkund…)
    - in a thesis, plagiarism detection implies thesis annulment

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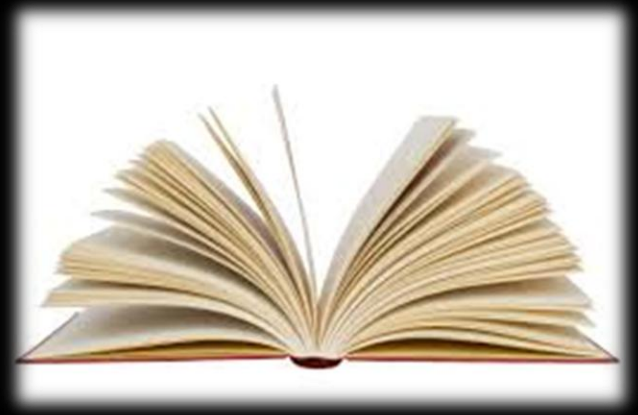
Dissertation/thesis

- It's a written document to be evaluated by a jury , that displays:
  - the proof that you can do research and deserve your award
  - a demonstration of full mastery of the subject (you have become an expert!)
  - awareness of alternatives to your approaches
  - the main contribution of your own research to the field of knowledge

Dissertation/thesis (cont.)



- It should be:
  - no longer and no shorter than absolutely necessary
  - well structured, articulated, coherent and cohesive overall
    - not a novel, not a poem, no twists
  - logical and crystal clear ('fog' is not impressive, it is confusing)
  - rigorous, yet fluent and pleasant to read (think of your reader)
    - a bad document can **spoil** a good research
  - as coherent as possible with the initial thesis proposal
  - a document that 'tells a story', with a coherent argument throughout

Dissertation/thesis structure

- Typical main structure (IMRADC):

  - Title and keywords
  - Abstract
  - Introduction
  - Methodology and methods
  - Results
  - Discussion
  - Conclusion
  - List of references

Items to include in each chapter:

see Appendix II

Dissertation/thesis structure

- Other items:
  - author's affiliation
  - table of contents
  - list of symbols
  - list of figures and tables
  - appendices
  - acknowledgments
  - dedication
  - ...

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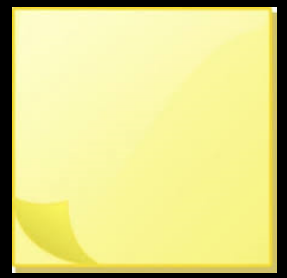
Memory: two extremes

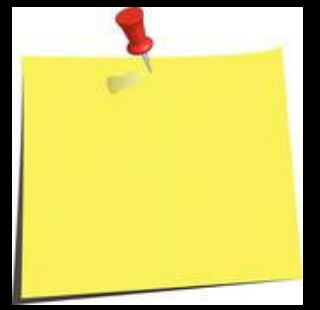
- Senility, Amnesia, Alzheimer's

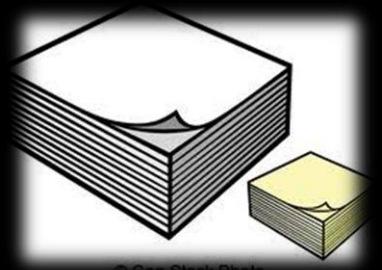
- Elephant's memory

A piece of friendly advice…

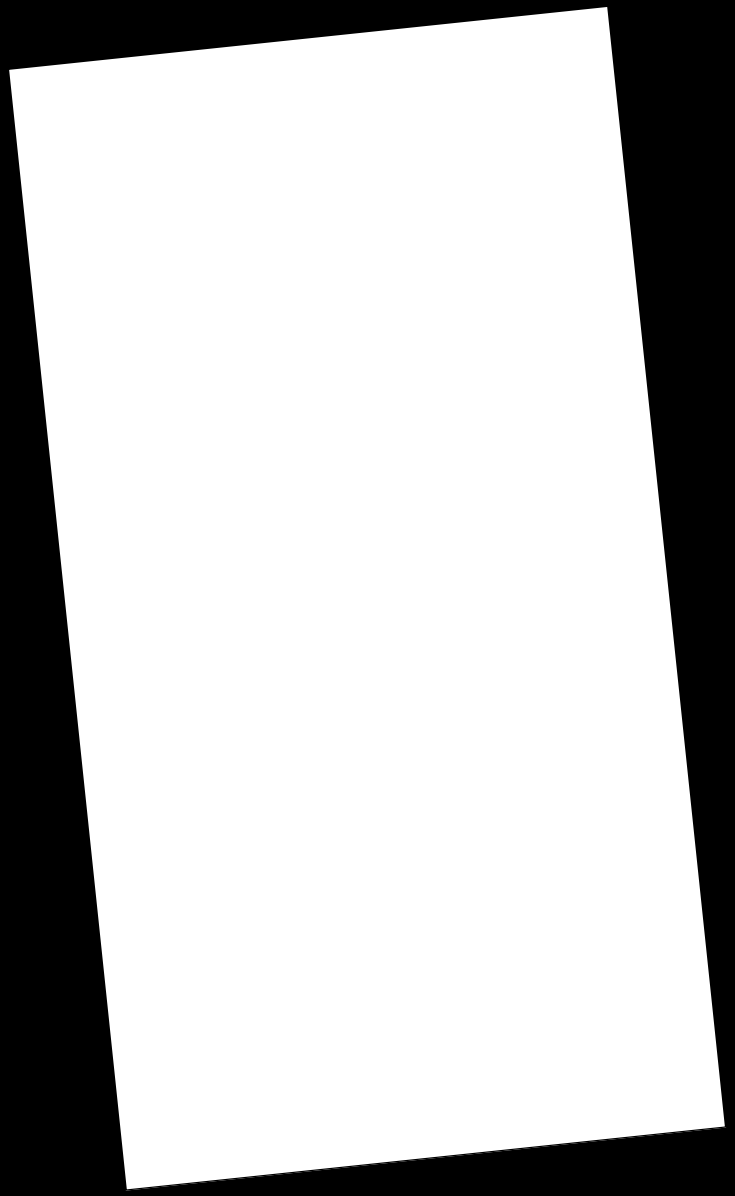
- Thinking you have an elephant's memory??!! Forget it, you don't!!
- You'd better take notes…
- … of EVERYTHING!!
  - literature review
  - research phases
    - numerical methods – description
    - measuring devices – characteristics
    - results
    - …
- EVERYTHING!!!!
- Really EVERYTHING!!!!!







The writer's block…



Blank page

Well-known syndrome

Two pieces of advice…

1 – Don’t panic:

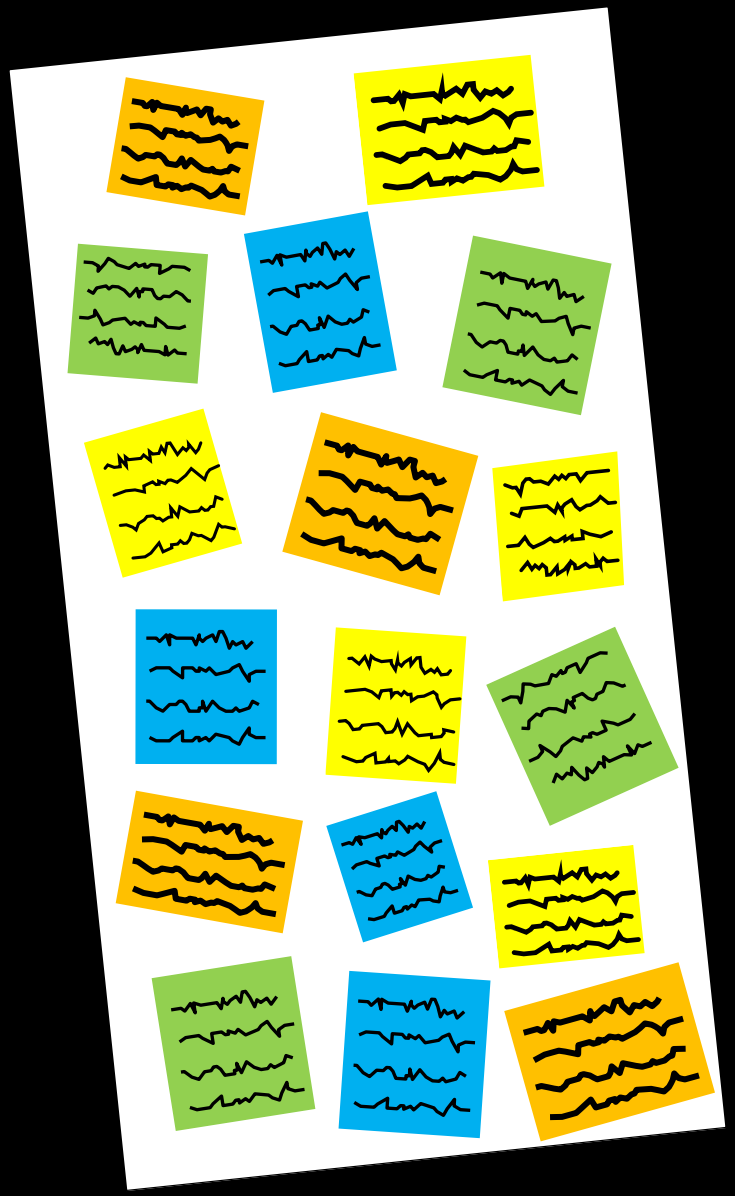
you are not the only one!

2 – Never give up!

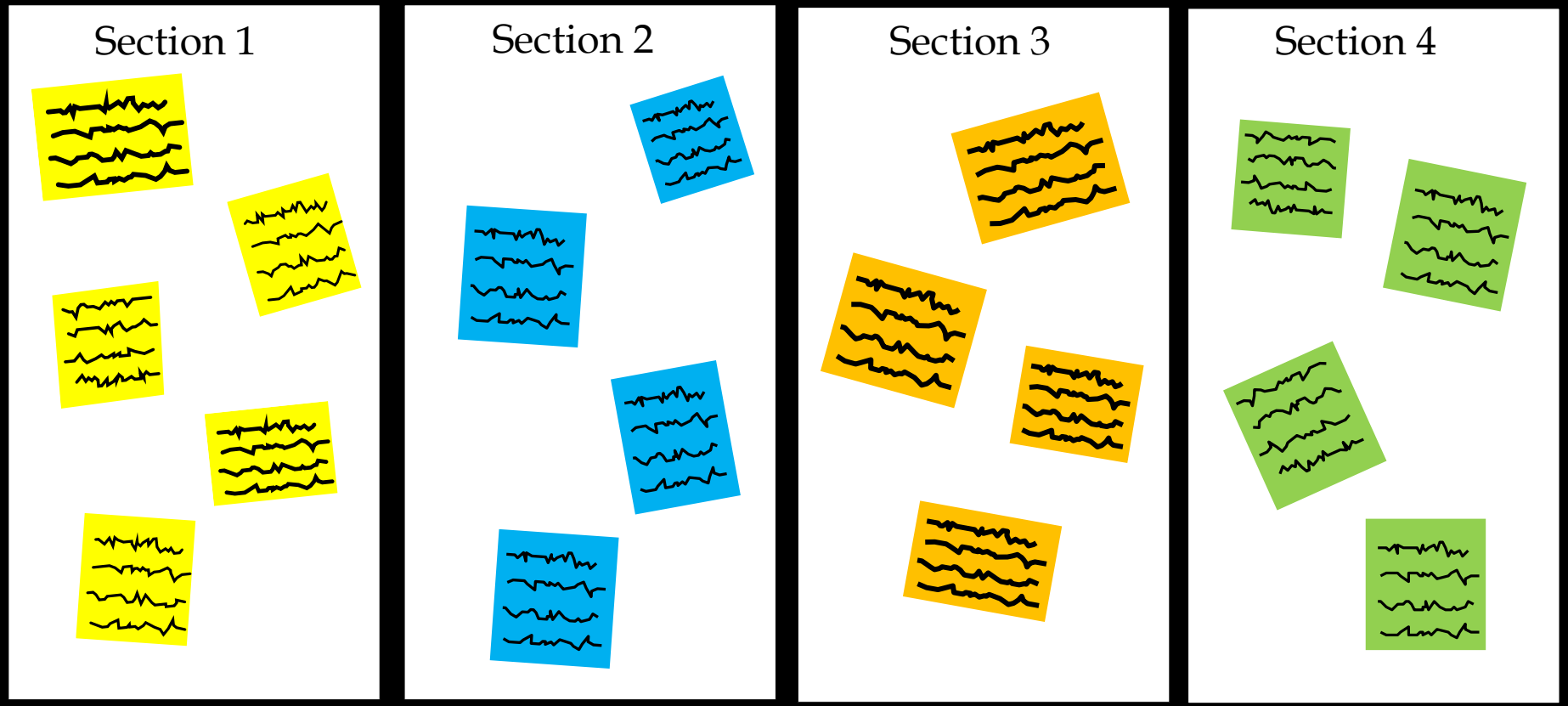
Easier said than done?

Not necessarily!

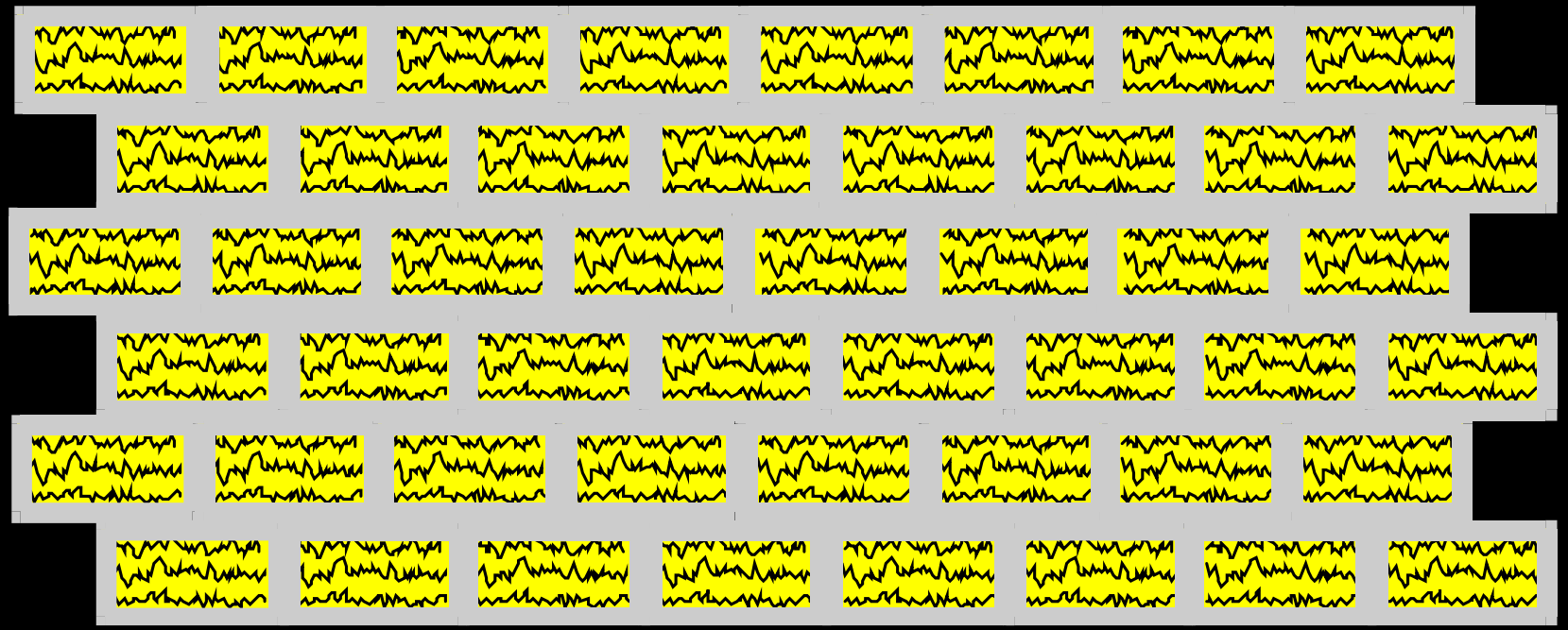
Facing the blank page



Subdividing into sections/chapters



In the writing 'building'…



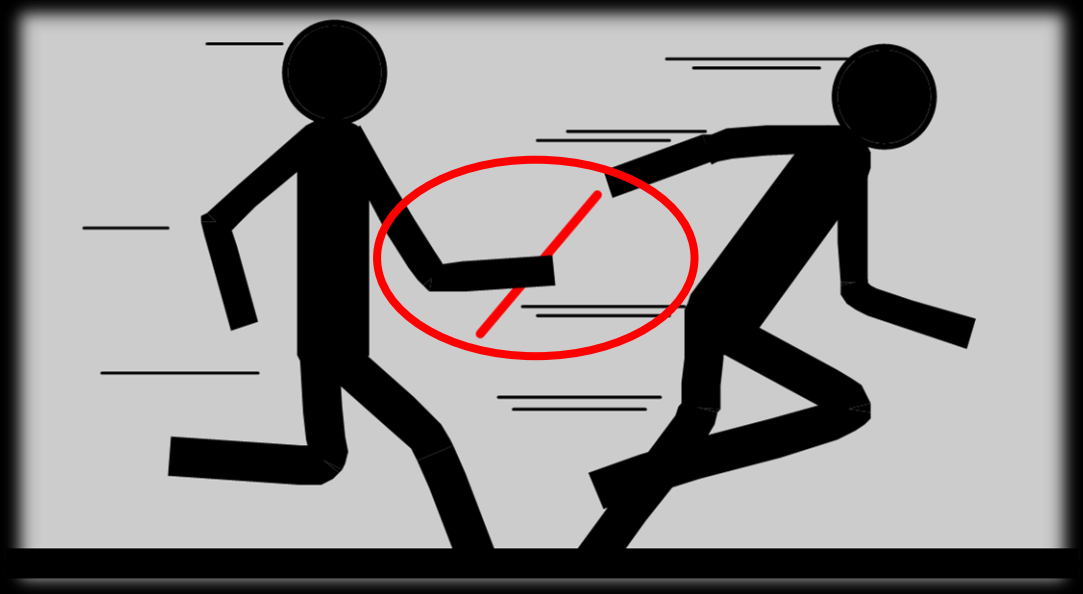
Sparse notes ⟷ free bricks, wall collapses

Text 'cements' notes ⟶ consistent writing

Scientific writing

- Not a romance (no fiction)
- Not a poem
- Simple style, clear, rigorous, streamlined
- Time is linear

Scientific writing is like a relay race: the baton must be passed on



- Valid for the three levels of text structure:
  - macro: linking chapters and sections
    - every main chapter should contain a small introduction and a brief conclusion
    - it's all about ensuring global coherence
  - meso: linking paragraphs
  - micro: linking sentences

Linguistic rigor, always!

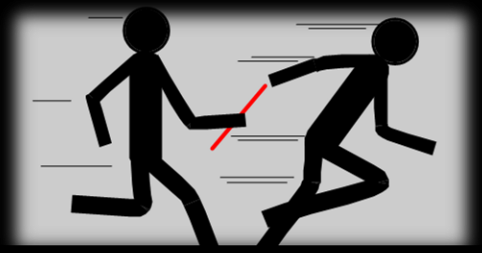
Omission of a simple comma may transform a friendly person into a frightening cannibal!!

Always put yourself in the place of the reader

- Respect the reader's:

  - time
    - text as brief, clear and concise as possible
    - non essential material is transferred to 'complements' (appendices, links…)

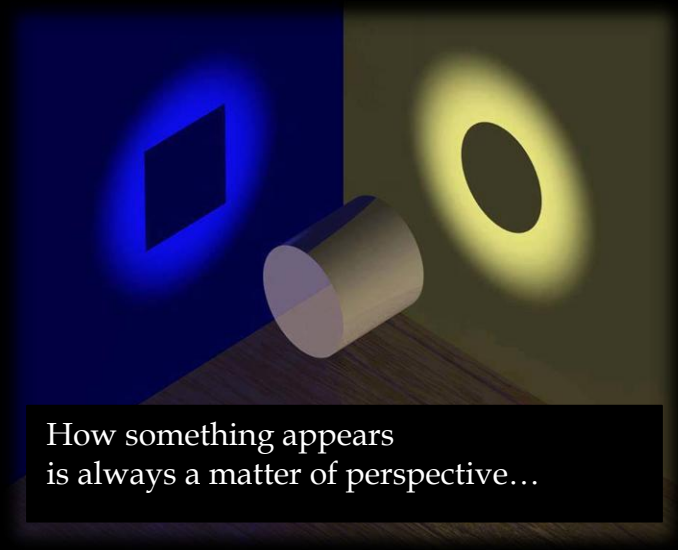
  - intelligence and culture
    - be simple, digestible for a great diversity of readers → team work
    - address the reader's way of thinking
      - ✓the 'baton image' also applies to arguments



  - interest
    - focus on what the reader needs or wishes to know or do, after reading your text

The power of image

selfie

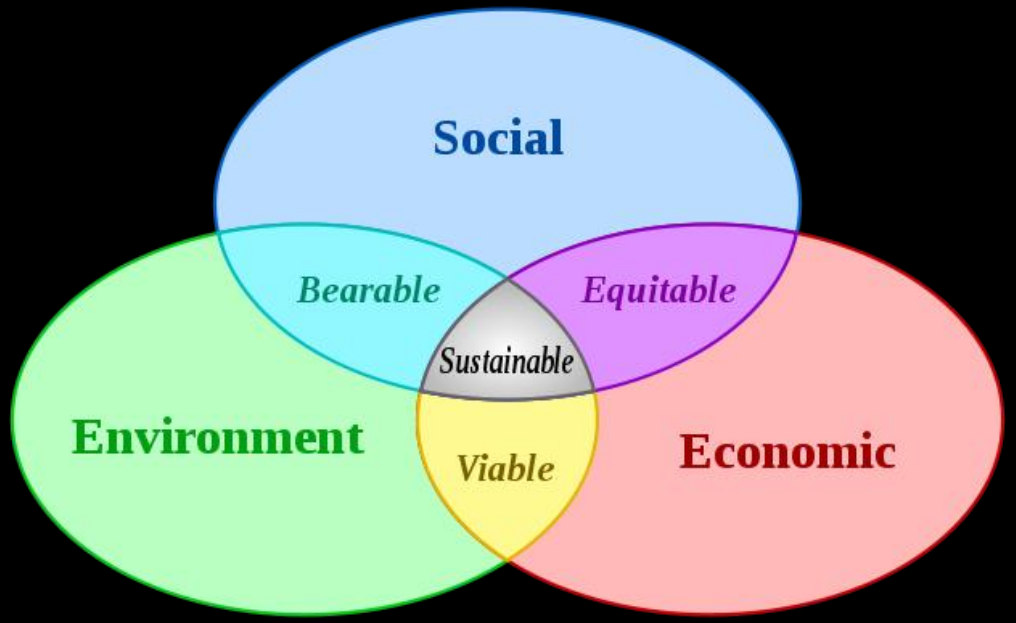


How something appears
is always a matter of perspective…

The power of visual aids

- Images, diagrams, pie charts, graphs…

  ✓ "A picture is worth a thousand words" (and numbers!!)
  ✓ again: "Graphs are the language of data" (Steven E. Koonin)



Venn diagram of sustainability

Integrity of the writing process: the role of Generative Artificial Intelligence (Gen AI)

- ChatGPT (from OpenAI) and alike
  - nothing prevents me from asking a friend's opinion…
  - …but I cannot claim that opinion as my own!
  - the same applies to using a chatbot
  - excellent tool to:
    - face and overcome the 'blank page syndrome'
    - focus and fine tune the search leading to a literature review (see Appendix II)
    - a lot more…
  - provides generators (presentations, project proposals, images, videos…)
  - to use with great care!
    ✓ChatGPT - and alike - can 'hallucinate'
  - in rapid evolution (ChatGPT 4.0 is presently free of charge…)

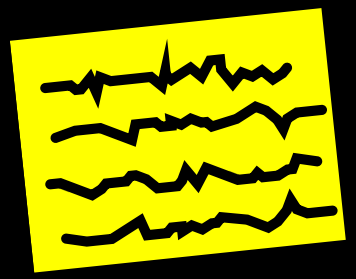
- There exist alternatives…
  - Copilot, Perplexity, Gemini, DeepSeek, Claude, Grok, Meta AI, Alexa, Siri…

- There exist detectors of GenAI authorship…
  ✓https://openai-openai-detector.hf.space

Useful suggestions for writing

Text edition– recommendations

- Writing a text is like a small project

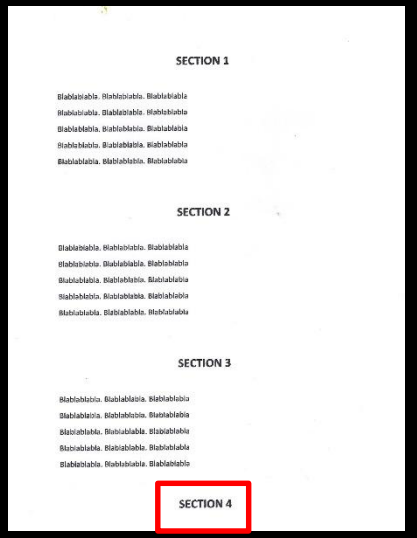


- Before starting: build up a general plan (≈ 1 page) with a list of topics to include (again, the notes…)

- To start, see the text as a first draft, rather than the final version
  - first, write as you speak; then improve, iterating (a lot…)

For the discussion

- Short, focused sentences
- One main idea per sentence
- Short paragraphs (no more than 6 lines)
- Fully respect FORMAT UNIFORMITY
- Use spelling and grammar corrector (no excuse!)
- Check general layout (headline at page bottom…)
- Avoid abbreviations
  - except for units, references, acronyms
- Always take notes
- Always backup



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Concluding remarks

- Scientific writing was addressed in different contexts
  - as a means of communication
  - in its daily practice (hands on)

- A bad text can spoil excellent contents

- Never underestimate the necessary time for writing:
  - it is probably the most time consuming phase of research
  - many scientists do not ‘exist’ because they can’t report

Concluding remarks (cont.)

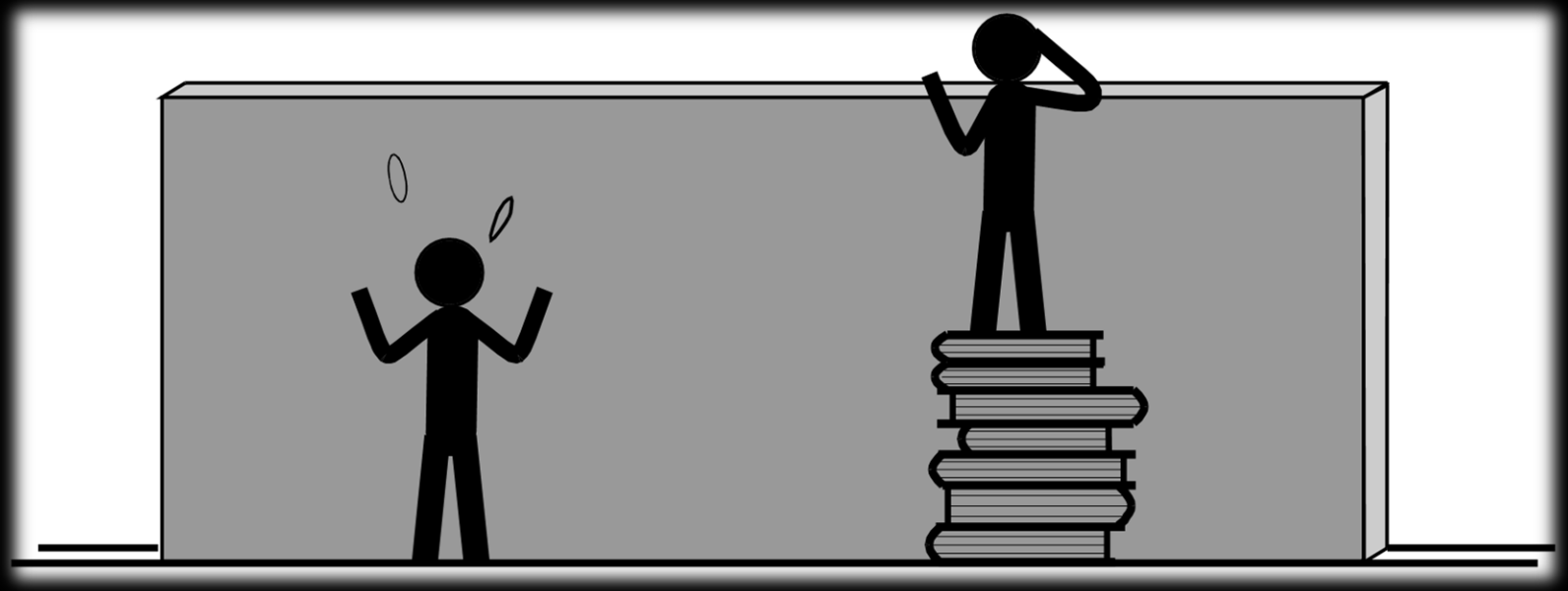
- Science is legitimized by data and strong arguments:
  - the role of scientific writing is to communicate that legitimacy

- Scientific writing is also an **art**:
  - the art of sharing science

- "Good scientific writing is not a matter of life and death: it is much more serious than that!"

  (Gastel & Day, 2019)

A guide of good practices will never replace cultural skills …



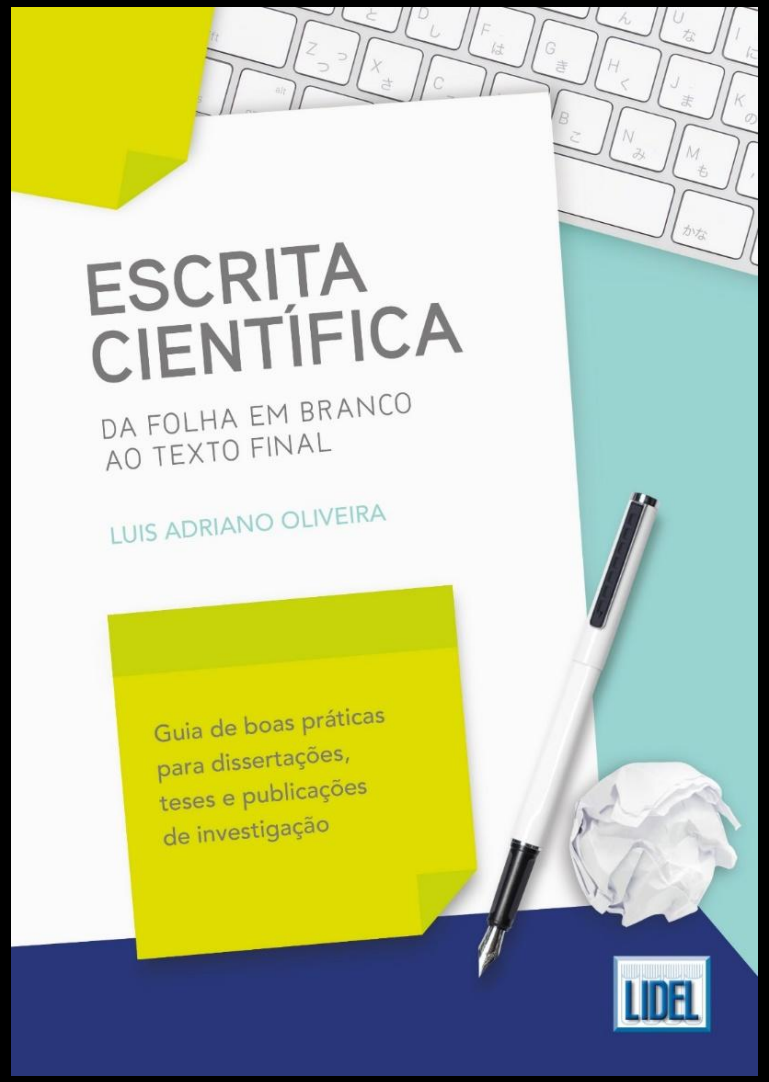
… but it may help!

Once you have finished writing your text, one final, crucial step:

Celebrate! Cheers!!

Questions?

COMPANION BOOK



Guide of good practices
with illustrative exercises
(in Portuguese)

OLIVEIRA, L. A. (2018), "Scientific writing: from the white sheet of paper to the final text" (in Pt.). *Lidel*.

Appendix I

Further reading

Further reading - I

- ALLEA. (2023). *The European Code of Conduct for Research Integrity* (Revised ed.). Berlin. https://doi.org/10.26356/ECOC
- Anderson, M. S., & Kleinert, S. (2013). *Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations*. Third World Conference on Research Integrity, Montreal, Canada, May 5–8, 2013.
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Further reading - II

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Further reading - III

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Appendix II

Items to include in a typical thesis structure

Title

- "Dreams do not have titles"
- A scientific text cannot exist without a title!!
- Title
  - two or three lines
  - contains context (keywords), your research question, your contribution, rather than just the field of research: **what**; **how**; **what for**
  - the art of synthesis

Abstract

- The document that will pop up in library searches
  - often, the first section that the public (jury, in a thesis) reads
  - invites readers to go through the remaining text
    - extended version of the title
    - reduced version of the whole text
  - accessible to a diversified public
  - should be able to stand alone (self-contained)
  - typically, less than 500 words (a summary, < A4 page)
  - **why** (context, question); **what**; **how**; **what main findings**
    - ABT framework (And; But; Therefore)
    - hourglass-type structure
  - written in two or three languages

Introduction

- Often the last section drafted ...
- Context of the research and its motivation
  - why it is important (answer to "**so what?**")
- Literature review:
  - sometimes may be a chapter on its own, and/or be revisited along the thesis
  - should contextualise your work
  - **state of the art** [not just a collection of readings ('data dump')]; knowledge gaps
  - **shows that there is room for new research: yours**!
- Thesis roadmap:
  - main contents of each chapter
  - how chapters are mutually linked (global coherence)
  - roadmap should be respected and revisited at each main chapter:
    - in the introduction
    - in the conclusion

Generative Artificial Intelligence and literature review

- Steps to follow in the literature review
  - searching and querying, using scientific databases
    - Scopus; Google Scholar; Publish or Perish; DOAJ; Science Direct; IEEE…
  - fine-tuning your search, using Gen AI
    - NotebookLM…
  - selecting and retrieving your references
    - Scopus; Google Scholar; Publish or Perish; DOAJ; Science Direct; IEEE; arXiv.org; engrxiv…
  - storing and managing your references
    - Mendeley; Zotero; EndNote…
  - note-taking and highlighting
    - Mendeley; Zotero; EndNote…
  - In-text citing and listing references
    - example: Word + Mendeley Cite (formats APA, MLA, Chicago…)

Methodology and methods

- Theoretical tools
  - description
  - precision (error analysis)

- Laboratory tools
  - description
  - precision (error analysis)

- Other type of tools
  - field measurements, interviews, queries, surveys, questionnaires…

- Critical analysis of the approach adopted
  - why it was adopted
  - comparison with other alternatives
    - advantages and disadvantages

Results

- Not the whole set: just those needed to back the final conclusions

- Results can come up from:
  - theoretical predictions
  - laboratory or field measurements
  - if applicable, information collected via interviews, questionnaires, queries, surveys…

- Presentation uses a **logical** structure, not a chronological one

- One paragraph for each study or analysis:
  - Ex.: "To investigate how A depends on B, we measured… We found that… This behavior suggests a strong dependence of A on B."

- Using figures (graphs…) or tables can help illustrate and clarify
  - "Graphs are the language of data" (Steven E. Koonin)

- Ethics: any **manipulation** should be clearly announced
  - results are the objective grounds of discussion and final conclusions
  - the respect of ethics must be (and also look!) above suspicion
  - the **trust** that the work needs to inspire is at stake

Deposit in public repositories

- Applicable to:
  - results and also methods used to generate them
- A growing trend or even requirement
  - most common in open science publications
- Benefits for both authors and readers
  - reinforces reproducibility, a crucial ethical requirement!
  - promotes collaboration, networking, teamwork
    - data sharing, work citations, detection of errors…
  - data can be reused anytime, up to 10 or 20 years from deposit
  - privacy is generally respected until publication
- Repositories may vary according to the scientific domain
  - https://zenodo.org; https://github.com; https://arxiv.org …

Discussion

- What you get (physical meaning) from what you find
  - progressing from information (results) to knowledge
- Test, verification, validation
- Parametric exploration and analysis
- Interpretation, speculation, creative leaps and ideas, articulate ideas and findings
- Are the results 'favourable' or 'unfavourable'?
  - '**outliers**' is perhaps more adequate than 'unfavourable' (not misleading)
  - iteration: was there any need for recycling results?
- If necessary, results can be simultaneously presented and discussed

Conclusion

✓often, the second chapter that the jury reads…

- ❑ Again, a summary of the work (**why?**, **what?**, **how?**)
- ❑ Main findings
  - was the main question actually addressed and answered/solved?
  - is your research a contribution to the field of knowledge?
    - highlight **original aspects**
    - highlight merits of the research work
  - can your results be generalized?
- ❑ Main recommendations (if change is suggested)
  - action: how to implement new ideas

- ❑ Main limitations/reservations/weaknesses should be acknowledged
  - what limitations
  - why
- ❑ Thoughts and suggestions for future work

In-text citations

- Calls, in the main (body) text, for sources of information:
  - books and/or book chapters
  - journal papers, conference communications
  - Websites, articles in the Web
  - other sources

- Author-date system (Harvard system) identifies:
  - name of author(s)
  - year of publication
  - for direct quotation and the like: page number or page range
    - ✓ Gastel & Day (2016, p. 153); Gastel & Day (2016, pp. 153-158)

- Numerical system (Vancouver system)
  - each source cited in the body text is denoted by a number in brackets
  - the number identifies the entry of the full reference in the reference list
  - numbers in brackets are arranged by the order in which citations occur
    - ✓ Gastel and Day [1] have stated that…; Turabian [2] showed the relationship…

List of (full) references

- List of sources that have been cited in the body text

- Author-date system (Harvard system)
  - the reference list is usually arranged by alphabetic order of authors
    - ✓ Example:

      GASTEL, B. & DAY, R. (2016), "How to Write and Publish a Scientific Paper" (8.th ed.). *Greenwood*. USA.

      THIEL, D. V. (2014), "Research Methods for Engineers". *Cambridge University Press*.

      TURABIAN, K. L. (2013), "A Manual for Writers of Research Papers, Theses and Dissertations" (8th ed.). *The University of Chicago Press*.

- Numerical system (Vancouver system)
  - the references are listed in numerical order as they appear in the text
    - ✓ Example:

      [1] GASTEL, B. & DAY, R. (2016), "How to Write and Publish a Scientific Paper" (8.th ed.). *Greenwood*. USA.

      [2] TURABIAN, K. L. (2013), "A Manual for Writers of Research Papers, Theses and Dissertations" (8.th ed.). *The University of Chicago Press*.

      [3] ANDERSON, M. & KLEINERT, S. (2013), "Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations". *Third World Conference on Research Integrity*. Montreal, Canada, May 5-8, 2013.

Citations *versus* references

- Two-way correspondence:
  - in general, references do not include all the works consulted
  - instead, there should be an exact match between the sources cited in the main text and those that appear in the list of references. Meaning:
    - all references must be cited; all citations must be referenced

- Author-date (Harvard) system can use different styles
  - APA (American Psychological Association)
  - MLA (Modern Language Association)
  - …

- Whatever the style you adopt:
  - respect style uniformity throughout the whole document
    - this is a common source of error, easily avoided!
  - software is now available for adding citations and references

Appendices, footnotes, endnotes

- Appendices
  - items deserving development, but whose development could disrupt the flow of ideas in the main text
  - ensure each one is labeled and referenced to where it is used in the body text

- Footnotes, endnotes
  - items deserving to be mentioned, but which you do not wish to treat in full. Could also include small details helping clarify the main text
  - footnotes appear in the footer of pages
  - endnotes appear collectively at the end of a chapter, or document
    - suitable option if there are too many notes on each page
  - footnotes and endnotes are denoted in the text by superscript numbers or symbols: [1], [2]… *, **…
  - software is available to add notes (e.g. Microsoft Word)

Other items

Symbol	Description	Dimensions
A	area	L^2
U_i $(i=1,2,3)$	velocity component	LT^{-1}

- Table of contents
- List of symbols
  - may be extremely useful (in clarifying, helping detect any lack of consistency in the symbols used throughout the whole text)
  - in the main text, each symbol used must be clearly identified as well
- List of figures and figure captions
- Acknowledgments
  - supporting institutions, thesis supervisor, colleagues, staff, friends, family,…
  - the style should be sober
  - Example: *This work has been framed under the Initiative Energy for Sustainability of the University of Coimbra and supported by the Energy and Mobility for Sustainable Regions - EMSURE - Project (CENTRO-07-0224-FEDER-002004).*

Figures / images

- They provide visual support for the narrative

- Each figure conveys its own main message
  - one single message (clearly stated!) per figure

- Data-ink ratio: (data-ink/total ink used to print the figure)
  - data-ink ratio should be close to 1
  - use color wisely, as well as other auxiliary effects

- Any kind of manipulation must be clearly stated (**ethical** requirement)

- Detailed information: links and other supports

Evaluation: the jury's point of view

- Evaluation addresses:
  - relevance of contribution to the scientific area
  - originality and innovation versus state of the art
  - autonomy and rigor while conducting the research
  - clarity and quality of written report (text, figures, tables…)
  - clarity and quality of oral presentation
  - capacity of the candidate to defend his/her work

Article in a journal, communication to a congress

- Main structure similar to dissertation/thesis, without chapters, just sections (~ 15 p.)

- Title
- Abstract
- Introduction
- Methodology and methods
- Results
- Discussion
- Conclusion
- References

- \+ :
  - keywords
  - table of contents
  - list of symbols
  - list of figures and tables
  - appendices and annexes
  - acknowledgements
  - ~~dedication~~
  - …